Project: PN-II-ID-PCE-2007-1
DEVELOPMENT OF A NEW CONCEPT FOR MANUFACTURING MACHINE CONTROL-HOLARHIC ATTRIBUTIVE CONTROL

2007 Annual Report

Planned objective:

Objective 1 - *Development of the concept of control using the holarhic attributive model and unsupervised online learning*.

Achieved activities:

1.1 Holarchic attributive model building for tehnological machines. Building a online unsupervised learning algorithm and implementation in a tehnological machine.

1.2 Model and algorithm integration in the holarhic attributive control using unsupervised online learning.

Achieved results:

1. **Holarchic-attributive model building**

The idea of building technical system as holonic systems is the endeavour to assure simultaneously, stability to disturbances from enviroment evolutions, by copying application of biological methods and systems found in nature to the study and design of engineering.

Firstly, it was defined several notions as it follows:

Tehnological holon In the endevour of averaging between atomic aproach and hollarhic one, Arthur Koestler took into account that, in the natural system, the part and the hole,does not exists. In a natural structure every structural element is a part of a high rank element, and in the some time, a hole, builded from another parts, inferior rank elements. The element was defined as holon, from holos (gr hole) and on (gr- part) (Fig.1). If the component elements of a tehnological machine have a relation of membership, than one element it is called tehnological holon.The main attributes of the tehnological holon are autonomous working and adapting to the perturbances of the enviroment evolutions.

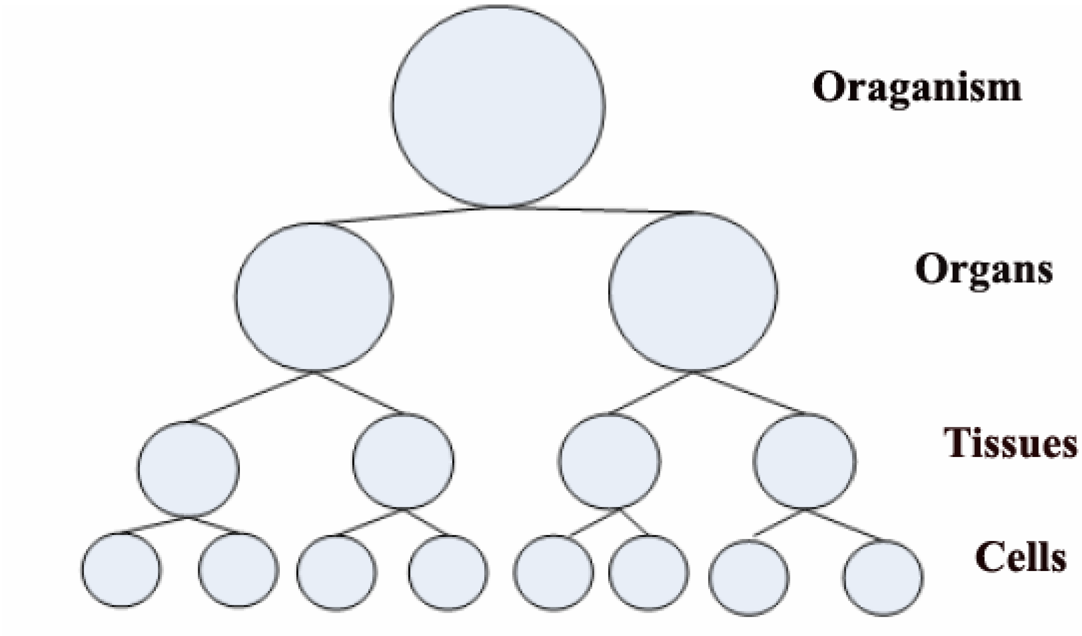

Fig.1 Natural holonic structure

Holonic structure If both hardware and software of a tehnological machine can be devided in holons, than we state that the maschine structure is a holonic one. From the viewpoint if structural analysis, the most important characteristics of a holonic structure are reconfigurability and discretisation.

Holonic Tree Holonic structures can be represented by a tree, having the main root its own assembly (the highest rank holon), and as leafes the holons that cannot be furthermore devided to loose tehnological holon characteristics. This representation is defined as holonic tree.

Holonic structure canon Besides belonging rellationships, between holons there are interdependencies rellations, that is stating the innern way of conduct, as well as the behaviour oh the holonic structure to the enviroment. The total amount of the rules used by the holons to interact it is named *holonic structure canon.*

Holonic structure functionality Between holons there are cooperation relations, assuring the functioning of the holonic structure. The cooperation is given by the functional attiributes of each holon in the structure. Depending of the gold of one holon, the functional attributes cand be syntethic or specific. Functional attributes defined as syntethic are for instance autonomy, cooperativity and optimital conduct. Functional attributes are for instance the movement to a certain direction or the computing according to a algorihtm. The total amount of functional attributes it is defined as *holonic structure canon*. The complexity of the working for a tehnological machine to be executed and the capacity to adapt to the enviroment are variables of the holonic structural functional.

Holarchy The assembly represented by the holonic tree, canon, and functional is it named holarchy. The holarchy can be defined as the descriptive model of a certain holonic structure.

The new notions defined, along with those previously defined in literature, modeled in the research program, are the base for the new control approach.

Tehnological machines -the machines used for the transforming the materials in the mechanical components.

Control –the actions that implies keeping the states of a machine to imposed values.

Comand control – the actions that means the change of the state value to the current state.

In the project the tehnological machine was designed as a holarchy, un-divisible and reconfigurable, where holons are autonomous, cooperative and optimal, and the canon represented by laws, behaviour, (natural – economical , fizical, or conventional – administrative/managerial rules). Entire holarhic design is oriented to the main gold, that is to get a better addaptability of the tehnological machine to the nowadays global economic enviroment.

Meeting the adaptability condition is based on:

a) *holarhic attributive control*, characterised that the adaption to the enviroment evolution implies the initial action the evaluation of the current attributes values describing the performance of the holarchy. The final action, as a result of this, is the changing the holarchy canon, as the target is to achieve maximum performance possible.
b) *Unsupervised online learning* is used for the holarhic attributive control, in order to assure the holonic autonomy of the tehnological machine, and therefore the capacity of integration in superior rank holonic structures.

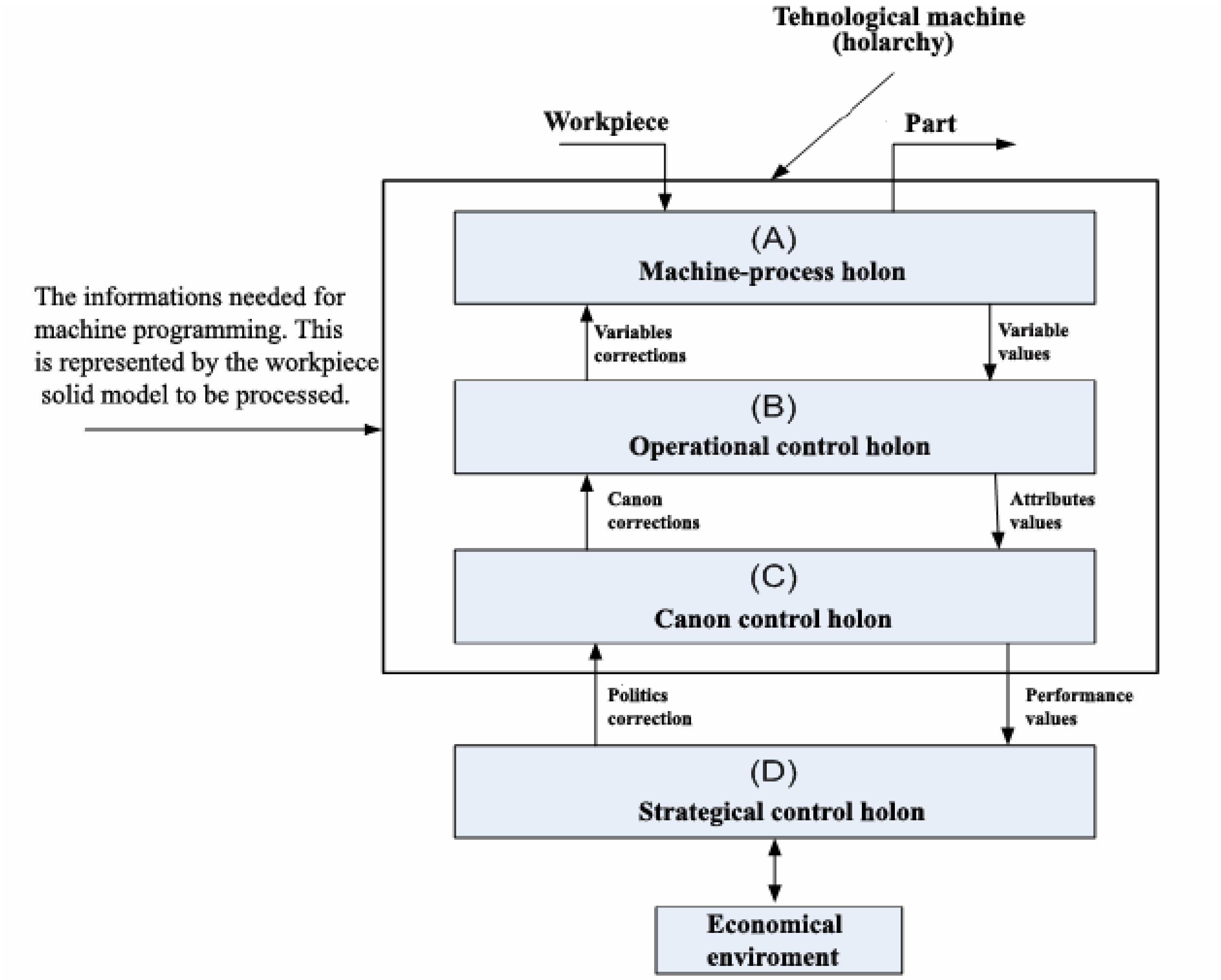

Fig.2 Attributive holarhic model for tehnological machine

In the first phase of the project it was designed the holarhic-attributive model (Fig 2) describing:

- *Machine- process- holon* it is designed as the model depicted in Fig.3 and the structure described in Fig.4;
- *Operational control holon* it is designed with the structure described in Fig.5;
- *Canonical control holon* inputs are the current values of attributes and the adjustement of politics imposed by strategy and the output the conventional rules needed;
- *Strategical control holon* imputs are the changes emerged in the economical enviroment and the current values of the performance variables; the uoutputs the political adjustment, needed to adapt to the economical enviroment for the tehnological machine.

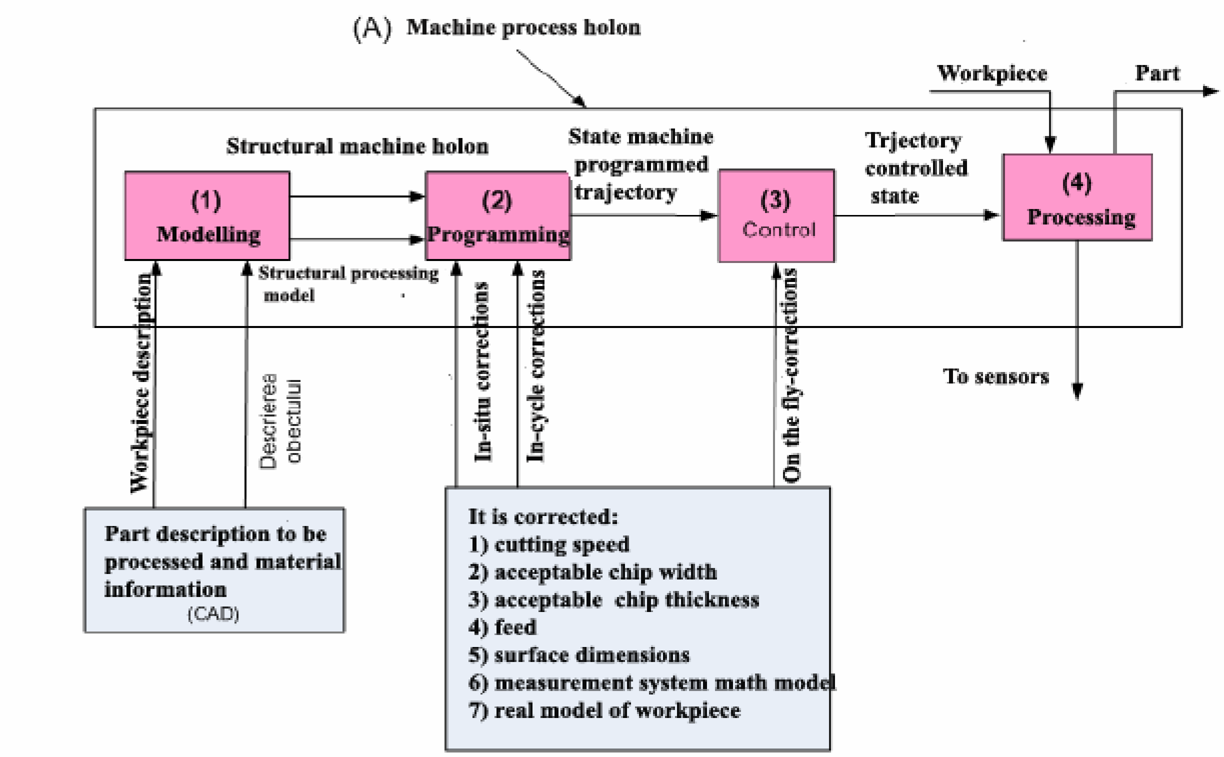

Fig.3 Conceptual model for machine holon

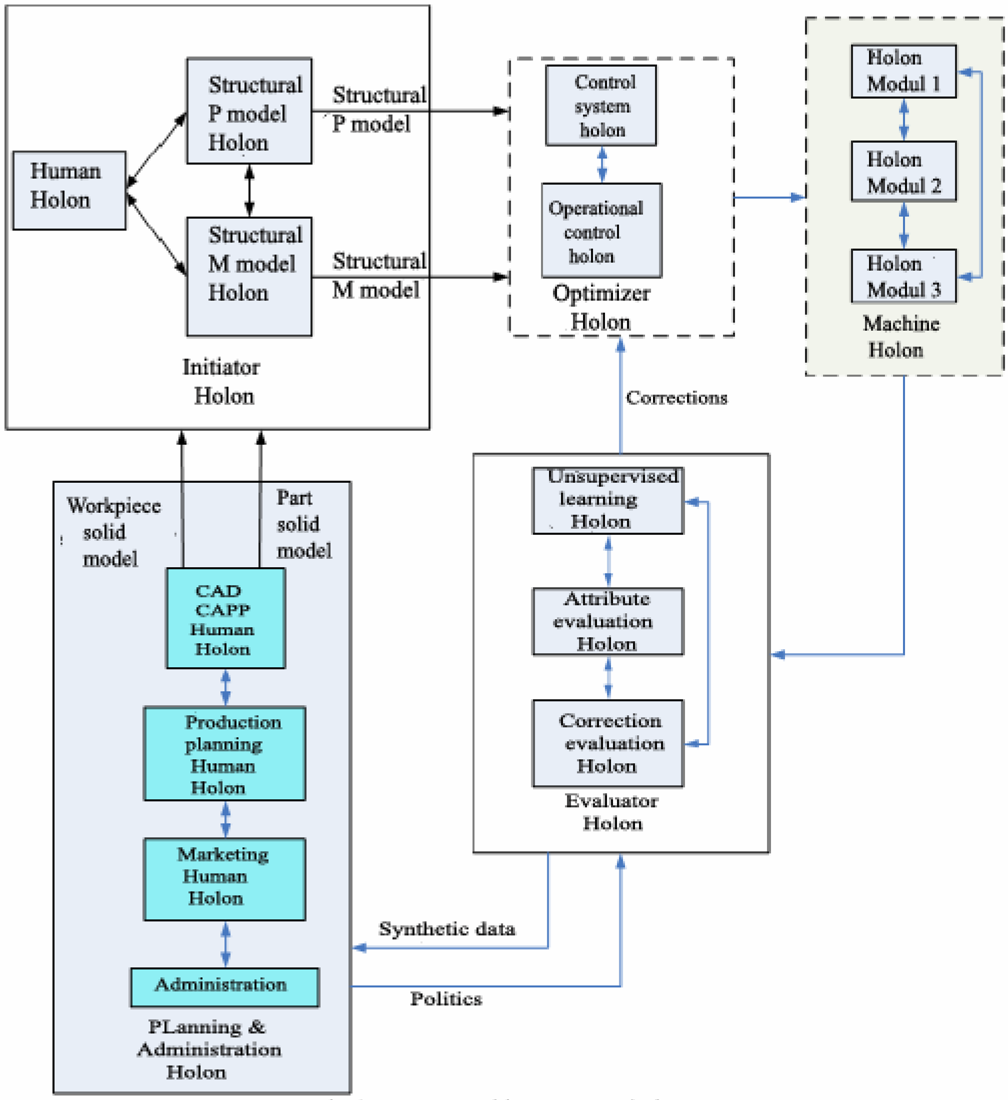

Fig.4 Process-machine structure holon structure

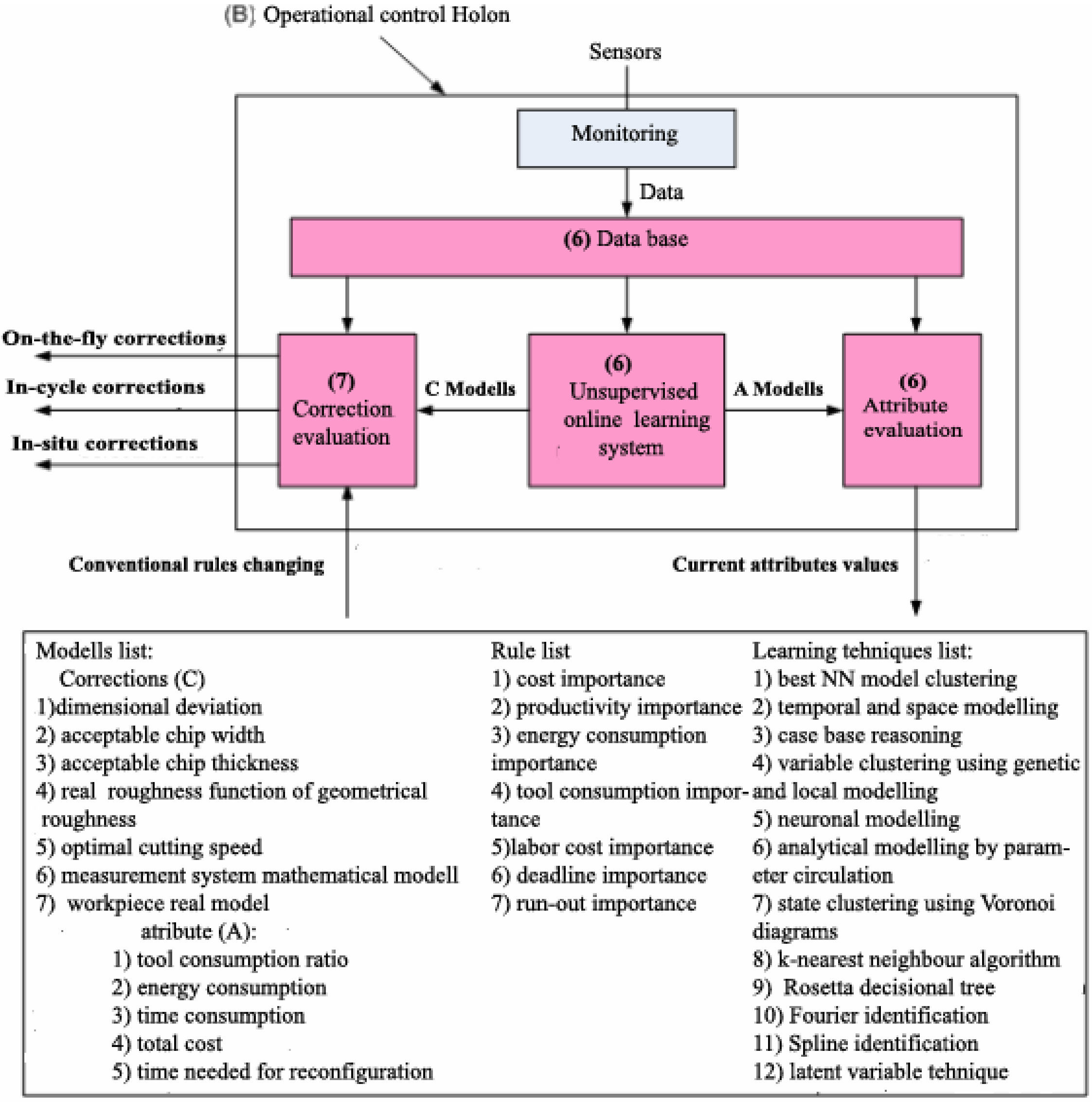

Fig.5 Operational control holon model concept

2. Designing of the unsupervised online learning algorithm and implementation to the tehnological machine control

Unsupervised online learning algorithm goal is to study the states and the tehnological machine transition, in order to get the state equations and the correction evaluation needed for the control. The algorithm is described by the following steps:

Step 1: *Variables clustering.* This is done based on the causal relation identificatoin, which are in the case of the unsupervised learning, unknown. The Tehniques are : NN best model, active interogation, corellation analysis, and neighbourhood statistical analysis.

Step 2: *Variable domain segmention*. The main gold in this stept of the algorithm is the building of simple models , local and temporal, to avoid the disadvantages occurred in the general models.

Step 3: *Learning space structuring*. This is accomplished using variable clustering and the variation segment divisation.

Step 4: *State space study.* Taking into account the observation that in the process of identical products, the system state is chaning after a close trajectory, described by the machine program, we can asser that successive trajectories are not very different. The differences emerged are the result of the fact that the workpieces used are not exactly identical, and the fact that the system behaviour is evolving. As the importance of the differences of the system behaviour is not considerable, it is to be noticed that the deviation from the trajectory not to be considerable. Therefore, in any point of the trajectory, the state equation can be linear by ysing Taylor series. Using this idea, it is easy to identify online the state equation.

Step 5: *Transition space study*. Defining the transition for the tehnological machine from a state to another, and using a correct metric, it can be defined a transition space. From this, using clustering tehniques, it can be defined equivalence classes. In the tehnological machine predictive control, the transition analogy can serve for state prediction. For this reason, the unsupervised online learning algorithm includes this step. The algorithm was tested on a data set , from a company that is producing car body for the pickup auto. Learning errors produced after simulation are considered accepted.

3.Model and algorithm implemention in the holarhic attributive model control and unsupervised online learning

In the Figure 6 is it represented the way the unsupervised online learning algorithm it is inputed with data, as well as the data are obtained, and the output structures.

Bibliography

[1] Leitao P, Restivo F. A holonic approach to dynamic manufacturing scheduling. Robot Comput Integr Manuf (2007),doi:10.1016/j.rcim.2007.09.005

[2] Verstraete, P., et al., Towards robust and efficient planning. Engineering Applications of Artificial Intelligence (2007),doi:10.1016/j.engappai.2007.09.002

[3] V. Marˇı´k, J. Lazˇansky´ , Industrial applications of agent technologies, Control Engineering Practice 15 (2007) 1364–1380

[4] J. Jarvis et al. A team-based holonic approach to robotic assembly cell control, Journal of Network and Computer Applications 29 (2006) 160–176

[5] Radu F. Babiceanu, F. Frank Chen – Development and applications of holonic manufacturing systems: a survey, in Journal of Intelligent Manufacturing, 17, (2006)111-131.

[6] J.L. Martinez Lastra, A.W. Colombo, Engineering framework for agent-based manufacturing control, Engineering Applications of Artificial Intelligence 19 (2006) 625–640

[7] S. Rodriguez et al. Towards a holonic multiple aspect analysis and modeling approach for complex systems: Application to the simulation of industrial plants, Simulation Modelling Practice and Theory 15 (2007) 521–543

[8] P. Valckenaers and H. Van Brussel ,Holonic Manufacturing Execution Systems CIRP Annals - Manufacturing Technology, Volume 54, Issue 1, (2005), Pages 427-432